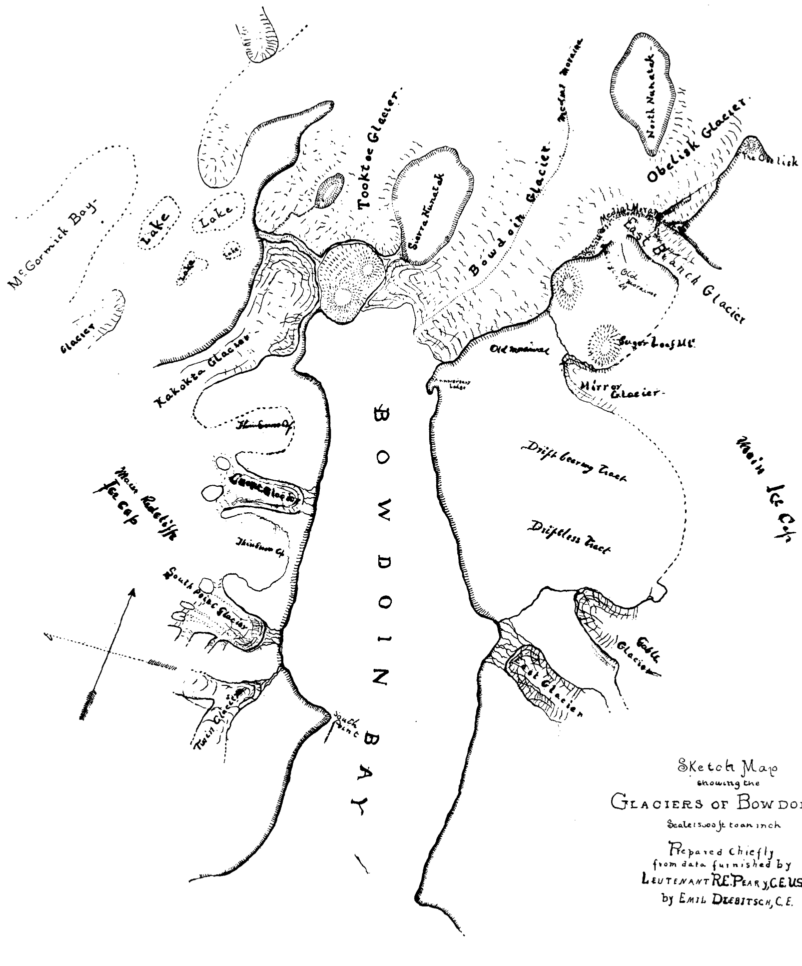


Sketch Map showing the Glaciers of Bowdoin Bay.

# GLACIAL STUDIES IN GREENLAND. VII.

## THE REDCLIFF PENINSULA.—*Continued.*

*Glaciers on the East Side of Redcliff Peninsula.*—The Fan and Bryant glaciers that have been previously described represent the group of ice tongues which protrude from the *mer de glace* of Redcliff peninsula on the south. A group of similar tongues push out toward Bowdoin Bay on the east, and two of these will now be described, the South Point glacier and the Gnome glacier. The general aspect of the east side of Redcliff peninsula is shown by the accompanying photographic illustrations. Together the two illustrations form a panoramic view. The point of observation is the border of the main ice-cap on the east side of Bowdoin Bay. The foreground is the edge of the plateau on which the main ice-cap lies. The depression that traverses the middle of the view is the valley occupied by Bowdoin Bay. The flat snow field beyond and the nearly level sky line show how truly the peninsula is a plateau and how far the glacial phenomena are different in general aspect from the Alpine type. At the extreme south lies the Twin glacier. Just north of it, but scarcely shown in the view, is the South Point glacier. At the left of the lower view lies the Gnome glacer. At the right hand of the lower figure the plateau may be seen to fall away to the low neck that connects it with the mainland. The geographic relations of these features may be seen by reference to the accompanying map of Bowdoin Bay and vicinity.

*South Point Glacier.*—This is a lobe of the peninsular ice-cap occupying a short valley notched in the edge of the plateau. Its width was estimated at one mile and its length at two. It descends from the plateau rather abruptly, as is the fashion of the valleys of the region. The ice as it makes its descent to the valley is interrupted by three islands around which it flows and from which it carries away medial moraines. These moraines,

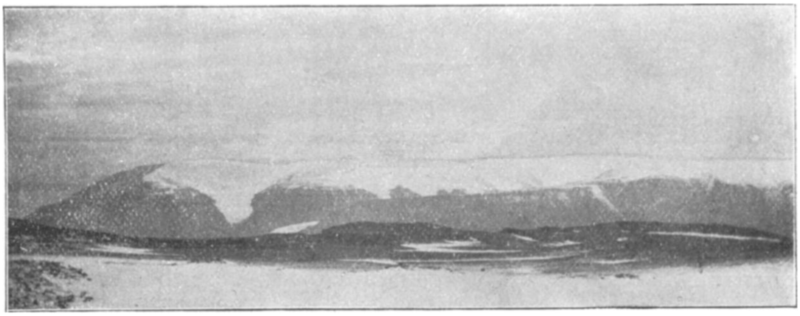

FIG. 43. General view of the south portion of the Redcliff peninsula, showing its snow-cap and the location of Twin and South Point glaciers. The point of view is the edge of the main ice-cap east of Bowdoin Bay, and the direction of view south-west. The immediate foreground is the wind-drift border of the main ice-cap which had been freshened and extended by a recent snow-fall. The main foreground is the edge of the plateau which extends backwards under the main ice-cap. The depression in the middle of the view is the valley occupied by Bowdoin Bay. Beyond lies the Redcliff peninsula. The Twin glacier occupies the valley at the left. The South Point glacier occupies a valley that begins a little to the right of the center of the view and extends towards the left, emerging at a point a little to the right of the Twin glacier where a small part of the glacier is seen. The horizontality of the summit plane is worthy of special note.

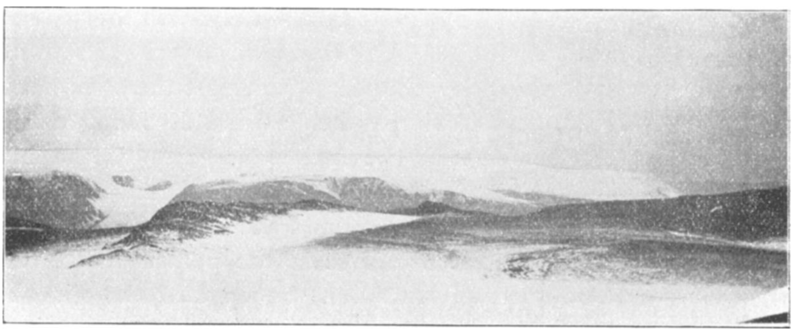

FIG. 44. General view of the north portion of the Redcliff peninsula, showing its snow-cap and the location of the Gnome glacier. Point of view the same as in Fig. 43, of which it is the complement. At the right the surface descends abruptly to the low ground that connects the peninsula with the mainland.

however, curve outwards to the sides of the valley before they reach the end of the glacier. At least one lateral glacier joins the main one on the south, bringing in an additional moraine, but this is also carried to the side of the glacier before advancing far down the valley. On the south side also there is an interesting "hanging" glacier descending very steeply from the summit of the plateau. This may be seen in Fig. 45. This

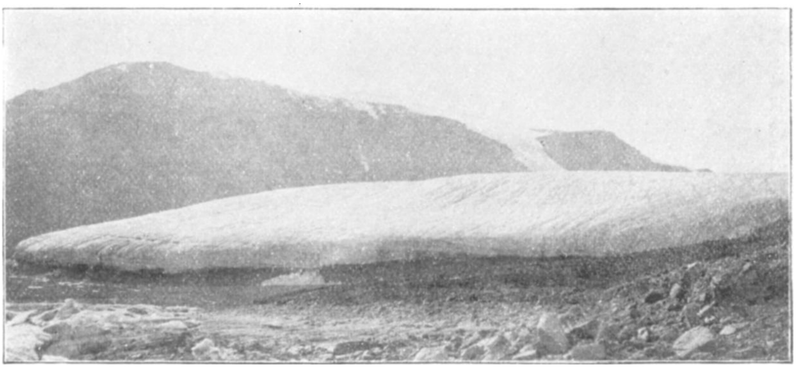

FIG. 45. View of the extremity of South Point glacier from a point on the north side of the valley looking southwesterly. The point of the glacier at the left is near the center of the valley, and a face similar to that turned toward the observer is presented beyond this point looking southeast. The dark band at the bottom is the talus slope and the bowldery layer of the glacier. The rather sudden change in the upper surface slope of the glacier is probably due to a terrace of rock extending across the valley and appearing at the edge of the glacier at the right. By a little care it will be seen that the bedding lines on the face of the glacier are continuous with those on the upper surface. The little steeply-descending glacier on the face of the snow-capped plateau in the background is the "hanging" glacier referred to in the text.

little glacier, however, is wasted and stayed at the foot of the steep slope before it is able to join the larger glacier. The measurements of its slope indicate that it reaches an inclination of twenty to thirty degrees in its steeper parts, but, singularly enough, it was not greatly crevassed, not even where it bent over the brow of the plateau.

South Point glacier stops short of Bowdoin Bay by perhaps half a mile. The interval is occupied by gravelly and bowldery

wash forming a sloping plain. On this the end of the glacier rests, except at the north edge, where it descends a rock terrace. There is a notable dropping down of the upper surface not far back from the end of the glacier, and this stretches well across

FIG. 46. Portion of the front wall of South Point glacier near the center of valley, seen looking southwesterly. The upper portion is nearly pure ice, but shows the stratification well. The dark ice at the upper edge of the talus slope is the bowldery layer mentioned in the text. The material of the talus is chiefly derived from this. The blocks of ice on and at the foot of the talus slope are masses detached from the glacier.

the valley, as seen in Fig. 45. It suggests that this rock terrace extends far out under the ice in the bottom of the valley. Owing to this or some other cause the glacier's upper profile is less symmetrical than those of the Bryant and Fan glaciers.

The most interesting feature of the glacier is its frontal edge. The view shown in Fig. 45 partially illustrates its character. It was taken from the northeast, looking obliquely across the axis

of the glacier. A view from the southeast would show a very similar face and the two combined would make up the extended terminal curve of the ice lobe. Fig. 46 is a nearer view in the middle of the valley, and Fig. 47 is a still nearer one on the

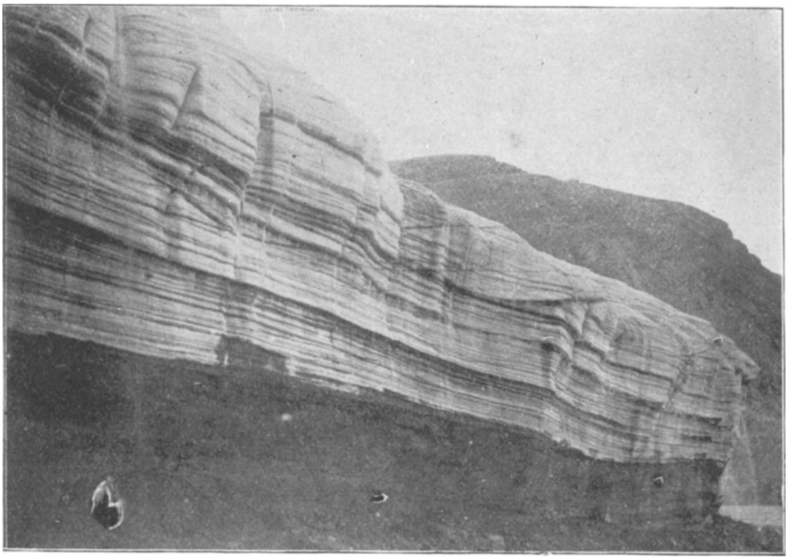

FIG. 47. Portion of front wall of South Point glacier near center of valley, seen looking northwesterly. The dark shading brings out prominently the stratification of the upper part, which is obscure in most of the views presented, because of the light color of all parts. The dark layer at the base and the talus slope are continuous with those of the preceding figure.

southeast face, looking in the reversed or northerly direction. These views, particularly Fig. 47, show the pronounced stratification of the glacier, the presence of débris between the layers, the development of a vertical and even overhanging face, and the formation of a notable talus slope in front. The stratification is much the same as that of the Bryant glacier, but more regular and pronounced in the upper portion where the débris is slight. It is worthy of note that these lines of stratification appear upon the upper surface also and may be traced consecutively

from this surface to the vertical face, as illustrated in Fig. 45. The lines which represent the outcropping of the layers on the surface form sweeping curves more or less concentric with the frontal edge of the glacier. By differential melting of these layers little steps or terraces are formed, which sometimes become somewhat pronounced. This phenomenon was observed on other glaciers.

As in the preceding glaciers — indeed in all the glaciers of Greenland that were seen — the upper part was found essentially free from débris, while the basal part was well inset with rock rubbish of various kinds. Along almost the whole face there was a layer twelve or fifteen feet thick at the upper edge of the talus slope that was so thickly inset as to be almost black with débris (Fig. 46). A part of this blackness, however, is attributable to the illusive effects of the surface wash. Much of the débris of this layer was coarse. Large bowlders were abundant, but all grades were present down to fine clay. When freed by melting it constituted a very coarse, stony till. Many of the fragments were rubbed, bruised, scratched or polished in typical glacial fashion. The assemblage of rock species was unusually interesting, embracing gneissic and igneous rocks and the gray and red sandstones. The walls of the valley and doubtless its bed were formed of the gneissic series into which had been intruded igneous dikes. Among these were some of a markedly green rock of diabasic aspect that was capable of receiving and exhibiting glacial markings with unusual facility. The sandstone series capped the plateau and formed the nunatakes at the head of the valley in the main. The distribution of the formations seemed to favor the view that the débris of the very bowldery layer above described was introduced at the cataract at the head of the valley.

The melting out of the débris of this bowldery layer at the frontal edge of the glacier was the chief cause of the formation of the pronounced talus slope shown best in Fig. 46. Its height varied from thirty or forty feet downwards. It gave the glacier the appearance of resting on a pedestal. This appearance was,

I think, with little doubt representative of the real fact in part, but it was also certainly true that the ice extended below the upper edge of the talus slope. The true bottom of the glacier was below its apparent bottom. I succeeded at points in tracing the ice under the talus at least half way down the slope. where the ice was uncovered under the talus its layers were curved upward at high angles, due I suppose to the relief of pressure above and to the resistance of the talus in front (Fig. 48). The concealed ice was less thickly set with débris than

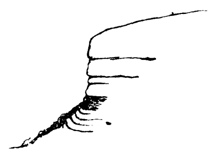

FIG. 48—Diagram intended to illustrate the probable curvature of the layers of ice under the talus in front of the glacier.

the layer above. If there were no other instances than this it might be questioned whether the pedestals on which so many of these northern glaciers seemed to rest were not illusions induced by misinterpretations of slopes of superficial talus derived from special débris-burdened layers of ice that happen to come out at some distance above the true glacial base, but the platforms of débris left by the retreats of some of the glaciers seem to show that there were true pedestals in some cases at least.

Inspection of the face of the glacier, as shown in Fig. 47, shows that certain of the layers of ice jut out over others very sharply. This was found to be a very common phenomenon, not only here but in most of the glaciers of the region. It gave the impression, at first sight, that the upper layers had been thrust forward over the lower ones. If this were the true interpretation, it would be a matter of radical value for it would indicate a mode of motion that has not, I believe, been recognized as a function of glaciers. It became, therefore, in the highest degree important to ascertain whether such was the real nature of the phenomena, or whether the impression was an illu-

sive one. It was very obvious from an inspection of the face of the glacier than wherever débris was embedded in it the radiant energy of the sun was caught and converted into sensible heat and melting was thereby promoted and so the darkened portions of the ice became sunken. From this obvious and very general fact, the suggestion arose that the overjutting layers were due to differential melting faciliated by the débris in the under layer. Observation showed that in most cases the under layer was darkened with débris and that it was therefore disposed to melt more rapidly than the overjutting layer which was usually white and free from débris. There was further evidence of like import in the fact that in some cases—indeed in many cases—the overjutting cornice when traced right and left was found to disappear simultaneously with the disappearance of the débris in the under layer. It cannot be supposed that there would be differential motion that would correspond accurately with the débris in the layers, although there might be a genetic connection between the formation of the layers and the introduction of the débris. Furthermore, in some instances the overjutting portion was too restricted in length and too sharply limited to accord with the hypothesis of differential motion. On the other hand, when it was found that the overjutting layers extended for long distances and that the projection reached two or three feet, and in some cases eight or ten or even fifteen feet, the hypothesis that the phenomenon was due simply to the superior melting of the underlayer seemed unsatisfactory if not untenable.

It occurred to me that if the upper layer moved over the lower layer, rock fragments at the junction of the two layers would give rise to fluting of the under surface of the upper layer as it was forced over it, and that perhaps evidence might be found along this line which would demonstrate the supposed mode of motion. I found upon the south side of the South Point glacier a very pronounced case of overjutting reaching an extent of two to three feet in which the junction plane between the upper and lower layers was corrugated and was marked by a

thin line of earthy and rocky material. The corrugations were not unlike those of the zinc facing of a washboard, except that they were on a much larger scale. I not only found that the débris layer was corrugated, but that for some inches below there were blue laminations of clean ice that were corrugated harmoniously with it. I succeeded in following these backward into the ice sufficiently to show that they were not simply superficial. Presumably they extended some distance along the junction plane. This phenomenon, it will be observed, is not precisely

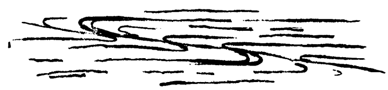

FIG. 49.—Diagram illustrating the phenomena of faulting and drag as seen on the south side of the South Point glacier.

that suggested above, but it has a bearing upon the interpretation of the fluted under surfaces of overjutting layers that were observed in very pronounced development in some of the glaciers yet to be described.

An observation was made on the south side of the glacier that bears upon the same question. On each side of a fracture plane extending obliquely across the ice layers, the laminations were bent toward the plane just as they are in the phenomena of faulting and drag (Fig. 49). There seemed no ground for doubt that there had been motion along the plane of fracture and that the ends of the laminations next to it had been bent backwards by the friction of the two faces. Similar phenomena were observed in several other places.

At another point upon the south side of the glacier there was a wide band of débris-set ice that zigzagged in a very irregular way from the summit of the ice cliff to its base. Fig. 50 is a representation of a sketch made upon the ground. The point at which this appeared was near the extremity of one of the medial moraines, and it seemed probable that this dark zigzag tract represented the junction of the two parts of the glacier that had united on the lower side of one of the nunataks

before described; in other words the two glaciers, instead of fusing, flowed side by side, crowding upon each other mutually and developing this zigzag line of junction. In addition to this very notable and unusual distortion, and in addition to the faulting and drag there were, at not a few points, twisted and contorted laminations indicating varying stresses and differential rates of motion.

FIG. 50.—Sketch intended to illustrate the remarkable zigzag course of a dark layer thickly set with pebbles and bowlders on the south side of the South Point glacier. The upper line of the sketch represents the upper edge of the wall of the glacier and the bottom its base.

On the south side of the glacier a stratum was observed thickly set with bowlders in very much the same manner as the stratum that formed the talus in front. The aneroid indicated that this was about 400 feet higher than the débris layer in front. Its distance back from the front unfortunately was not measured, nor was it traced continuously along the side and shown to be identical with the layer in front, but there seemed little ground to doubt that it was the same, and if so, it is worthy of note as indicating the rapid descent of the débris-bearing layer harmoniously with the descent of the entire glacier. The upper edge of the glacier was measured at a point not far above this and found to be about 550 feet above the base in front.

In respect to the interesting question of recent change in the extent of the ice, the evidence of the South Point glacier seemed very clear so far as it went. It has been remarked that between the glacier and the bay the valley was occupied by glacial wash. In the middle and northern half of the valley this was recent, but in the southern portion there was a terrace ele-

vated from ten feet upwards that was much older. It was very notably weathered and covered with vegetation in the scanty fashion of the region. In particular the bowlders were covered with lichens and were roughened and exfoliated by weathering in a way that indicated considerable antiquity. While comparisons with southern latitudes are liable to error because of the different climatic conditions, it may give some impression of the evidence of aging in the present case to compare these weathered and lichen-covered bowlders with the ruins of mediæval ages. Very possibly, however, they may not exceed a century in age, or even reach that. This older terrace extended to within 100 feet of the present edge of the ice, indeed, at the southeastern curve of the glacier where it turned away from the side of the valley, there was little more than room for the talus slope and the lateral drainage stream between the ice and the old valley débris. In harmony with this evidence, the talus slope of the valley cliffs on the south side, for the most part, was ancient, although somewhat disturbed and freshened at some points near the ice. It would appear, therefore, clear that the glacier has not, within recent times, advanced notably beyond its present position. It may, of course, have been advancing from some point of greater retreat, and may be even now advancing. The sharpness of the talus slope and the fact that it is no greater than it is, is best explained by supposing that the glacier is advancing with exceeding slowness upon the débris which is gradually accumulating at its front.

*The Gnome Glacier.* This is a smaller glacier occupying a narrower valley. It is only about 1800 feet wide, measured at a point above the terminal slope, according to Lieutenant Peary. It is closely beset with walls of gneiss on either hand, but judging from the erratics which it carries it reaches back to the sandstone series. Red sandstone covers the cliff on the north. The plateau on either side of the valley in which the Gnome glacier lies is capped with a thin stratum of ice, which, at some points, creeps out to the edge of the plateau, from which it falls in broken masses or extends itself downward in little hanging

glaciers. On the south side the edge of the Gnome glacier is quite extensively covered with fallen ice and débris from this source. The foot of the talus slope of the cliff on the north side is in close contact with the border of the glacier and indeed, in portions, has been carried away by it.

The Gnome glacier stops short of Bowdoin Bay by only a few rods, its terminal base lying but little above the sea level.

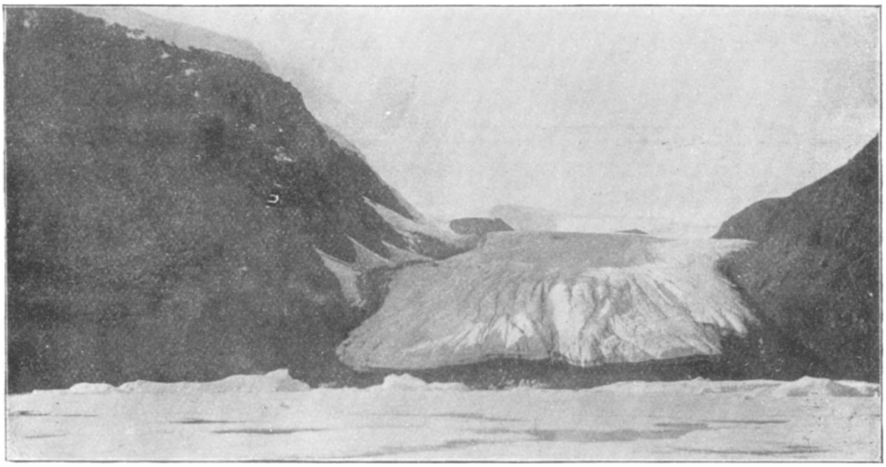

FIG. 51.—The Gnome glacier, seen from the ice of Bowdoin Bay. The dark layer at the base of the glacier and the talus slope are not distinguishable from the surrounding surface. Nunataks are partially shown at the head of the valley where the ice descends from the plateau. The steep border of the ice about them makes them appear as depressions.

It has an abrupt terminal face much like that of the South Point glacier. The upper portion consists of a thick stratum of nearly pure ice, showing indistinct lamination, the middle portion, of alternating dark and light ice, while the lowest exposed portion consists of a dark layer thickly inset with bowlders similar to the dark bowldery layer of the preceding glacier. Below this there is a similar talus slope but of greater height. The day of our visit was sunny and exceptionally warm, and the bowlders were being loosened from the dark stratum of ice and were fall-

ing at short intervals, rendering the ascent of the talus slope imprudent, and its height was therefore not measured. This was by far the most notable exhibition of activity seen in connection with any of the northern glaciers that end upon the land. In no other case during our visit was the loosening and falling of débris more than a rare event. The material contained in this bowldery stratum is in part very coarse, masses of rock several feet in diameter being not uncommon. As in the case of the South Point glacier, the talus slope here conceals the base of the glacier, and it was not ascertained how much of the talus slope represented a subglacial accumulation and how much merely a superficial concealment of the glacier's base. It was observed here, as in the preceding case, that the lamination of the ice under the talus slope stood at high angles, and had its strike approximately parallel to the face of the glacier, and this seems to be the prevalent fact in similar cases.

The laminæ of the ice are frequently twisted and distorted, and horizons of faulting and overthrust appear to be common, but they were inaccessible to close observation. The outjutting layers sometimes project two or three feet beyond those below. It would seem from the unconformity of the bent and crumpled layers that shearing action had taken place.

There are no abandoned moraines on the front or sides of the glacier. The sides of the valley showed some freshening and disrupting above the present edge of the ice, indicating that it had recently stood somewhat higher, but beyond this there was no evidence of any recent difference in extension. Beyond the exceptionally rapid melting of the face at the time of our visit there were but limited signs of activity.

T. C. Chamberlin.